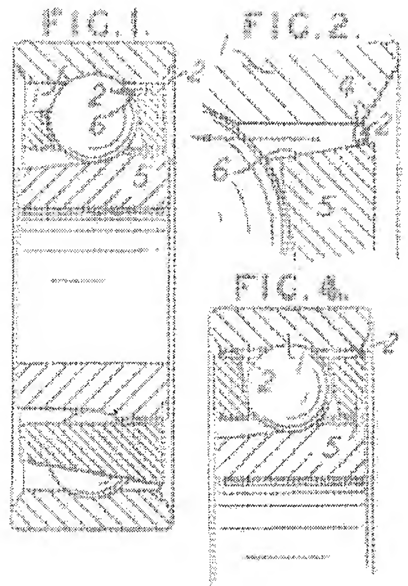
Improvements in or relating to ball bearings

Publication number: GB719829 (A)
Publication date: 1954-12-08
Inventor(s): DOWNES DOUGLAS GEORGE
Applicant(s): SPERRY GYROSCOPE CO LTD
Classification:
- international: ***F16C33/38; F16C33/66;*** **F16C33/38; F16C33/66**
- European: F16C33/46; F16C33/38; F16C33/66
Application number: GB19520015469 19520619
Priority number(s): GB19520015469 19520619

Abstract of **GB 719829 (A)**

719,829. Bearing cages. SPERRY GYROSCOPE CO., Ltd. April 24, 1953 [June 19, 1952], No. 15469/52. Class 12(1) In a ball or roller bearing, a cage 5 has an axially tapered outer surface 6 between which surface and the outer race 1 an annular gap is formed in which an oil ring 2 is established, thereby radially locating the cage 5. Oil flows along the outer surface of the cage due to centrifugal action. The outer race 1 may be chamfered to provide a sharp edge 4 at the gap or, alternatively, a groove may be formed in the outer race at that point. In a modification the cage is tapered axially in both directions, Fig. 4, whereby two such oil rings 2 are formed for locating the cage 5.



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PATENT SPECIFICATION

Inventor: DOUGLAS GEORGE DOWNES.

719,829

Date of filing Complete Specification April 24, 1953

Application Date June 19, 1952. *No. 15469/52.*

Complete Specification Published Dec. 8, 1954.

Index at acceptance :—Class 12(1), A5(B1 : C1).

COMPLETE SPECIFICATION

Improvements in or relating to Ball Bearings

ERRATUM

SPECIFICATION NO. 719,829

Page 2, line 64, *for* ".088" *read* ".008".

THE PATENT OFFICE,
10th February, 1955

DB 73712/2(9)/3524 150 2/55 R

age losses.

In general, power losses in bearings are due to two causes. There may be friction losses between the balls or rollers and the races, and between the cage and the balls or races, and also viscous drag due to lubricating oil between the surfaces of the various parts. Secondly, there may be losses due to cage vibration which may have axial and radial components.

In order to reduce losses light cages have been proposed, and it is known that cages of nylon are desirable because the viscous drag between nylon and oil is low, and its chemical inertness obviates sludging, i.e. the production of foreign bodies by chemical action, and in addition nylon has a low coefficient of friction with metals and high wear-resistance.

To prevent losses due to vibration of the cage it is necessary to locate the cage precisely without introducing large frictional losses. Formerly cages were located on the balls but the location was of necessity not precise, and any tendency to sludge caused foreign bodies to be introduced between the balls and cage to increase friction losses, and in low-loss bearings it is necessary to have a certain minimum clearance between the balls and the cage to prevent these losses, which clearance is too great to provide precise location of the cage. It is therefore thought necessary to locate the cage with reference to the races.

According to one aspect of the present invention in a ball or roller journal bearing [ ]

designed to be of such a size that the oil film cannot pass through it without being restricted in dimension, the surface tension of the restricted film partly balancing the centrifugal force tending to cause the oil to move outwards so that the oil will collect in the gap in an annular local concentration. The gap between the cage and the outer race may be of the order of .010″—.015″ for a race having an internal diameter of .5″ depending upon the viscosity of the oil used and the conditions, particularly the temperature, in the bearing. The ring of oil will acts as a cushion opposing and damping radial vibration of the cage.

Preferred embodiments of the invention are shown by way of example in the accompanying drawings in which:—

Figures 1, 3 and 4 show different arrangements of ball bearings;

Figure 2 is a part, to a larger scale, of the arrangement of Figure 1, and

Figure 5 shows a roller bearing embodying the invention.

As shown in Figures 1 and 2 the part of the outer race 1 at which the oil ring 2 is formed has a chamfer 3 which provides a sharp edge 4 which, together with the cage 5, defines the gap or neck. This is shown more clearly in Figure 2 which is an enlarged view of a part of Figure 1. The tapered part 6 of the cage surface is terminated in an edge 7 to which any oil which passes through the gap or neck will

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Index at acceptance :—Class **12(1)**, A5(B1: C1).

COMPLETE SPECIFICATION

Improvements in or relating to Ball Bearings

We, THE SPERRY GYROSCOPE COMPANY LIMITED, a British Company, of Great West Road, Brentford, Middlesex, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to low-power-loss ball and roller journal bearings. It relates more particularly to bearings having light thrust loads and to bearings in apparatus where the main load torque is that due to losses in the bearings and to windage. Gyroscopes are examples of such apparatus and these are frequently run in a vacuum to eliminate windage losses.

In general, power losses in bearings are due to two causes. There may be friction losses between the balls or rollers and the races, and between the cage and the balls or races, and also viscous drag due to lubricating oil between the surfaces of the various parts. Secondly, there may be losses due to cage vibration which may have axial and radial components.

In order to reduce losses light cages have been proposed, and it is known that cages of nylon are desirable because the viscous drag between nylon and oil is low, and its chemical inertness obviates sludging, i.e. the production of foreign bodies by chemical action, and in addition nylon has a low coefficient of friction with metals and high wear-resistance.

To prevent losses due to vibration of the cage it is necessary to locate the cage precisely without introducing large frictional losses. Formerly cages were located on the balls but the location was of necessity not precise, and any tendency to sludge caused foreign bodies to be introduced between the balls and cage to increase friction losses, and in low-loss bearings it is necessary to have a certain minimum clearance between the balls and the cage to prevent these losses, which clearance is too great to provide precise location of the cage. It is therefore thought necessary to locate the cage with reference to the races.

According to one aspect of the present invention in a ball or roller journal bearing the cage is held in position radially by an oil ring in contact with both the cage and the outer race.

Preferably the surface of the cage has a portion of which the outside diameter is tapered axially, between which portion and the surface of the outer race is defined an annular gap in which the oil ring will be established by oil flowing along the said portion of the cage.

Oil transferred through the bearing will travel by centrifugal force as a film along the tapered surface of the cage to positions of increasing radius until it reaches the co-operating part of the outer race between which and the cage the gap is defined. The gap is designed to be of such a size that the oil film cannot pass through it without being restricted in dimension, the surface tension of the restricted film partly balancing the centrifugal force tending to cause the oil to move outwards so that the oil will collect in the gap in an annular local concentration. The gap between the cage and the outer race may be of the order of .010″—.015″ for a race having an internal diameter of .5″ depending upon the viscosity of the oil used and the conditions, particularly the temperature, in the bearing. The ring of oil will acts as a cushion opposing and damping radial vibration of the cage.

Preferred embodiments of the invention are shown by way of example in the accompanying drawings in which:—

Figures 1, 3 and 4 show different arrangements of ball bearings;

Figure 2 is a part, to a larger scale, of the arrangement of Figure 1, and

Figure 5 shows a roller bearing embodying the invention.

As shown in Figures 1 and 2 the part of the outer race 1 at which the oil ring 2 is formed has a chamfer 3 which provides a sharp edge 4 which, together with the cage 5, defines the gap or neck. This is shown more clearly in Figure 2 which is an enlarged view of a part of Figure 1. The tapered part 6 of the cage surface is terminated in an edge 7 to which any oil which passes through the gap or neck will

travel, and from which it will be thrown off by centrifugal force. It may collect and run down the chamfer into the neck forming a local circulating system or may be collected on an external soak and returned to the reservoir. In this form of the bearing a certain amount of thrust in the direction shown by the arrow 8 can be taken up by the oil in withstanding compression. Thus axial vibration of the cage can be reduced. It is preferred that the internal diameter of the cage should be just larger than the diameter of the inner race. For example, a difference in diameter of about .006" is suitable for a .5" bore bearing. This causes the cage to be located to some extent during running of the inner race so that wobble can be reduced. Any location of the cage that is necessary apart from the location on the oil ring 2 is given by the inner race rather than the outer because of the smaller relative linear speed between the cage and the inner race. However, the clearance between the cage and the inner race may be large enough for there to be no location.

In another embodiment illustrated in Figure 3 the outer race is not chamfered but is provided with a circular groove 9 or recess to define the gap in which the oil ring 2 is to be formed.

In another example of the invention, shown in Figure 4, the outer surface of the cage 5 is generally spool-shaped having two surfaces 6, 6^1 of increasing radial dimension in opposite senses, the flat sides of the cage being formed with sharp edges 7, 7^1. In this example the outer race has two chamfers 3, 3^1, each of which is fed with oil from one of the sloping surfaces 6, 6^1 of the cage, and in each of which one of the edges 7, 7^1 of the cage is located. At the cost of slightly greater viscous drag this form of the invention provides substantial freedom from axial vibration of the cage in both directions.

In Figure 5 there is shown an example of the invention applied to a roll bearing.

In order that there will be no difficulty in constructing a bearing according to the present invention the relevant dimensions will be given of a bearing which has been constructed in accordance with the invention and has been found to work satisfactorily. The bearing is for a shaft of $\frac{1}{2}$" diameter. The cage has .005" clearance between the holes and the balls. The taper of the outer surface of the cage is 10° to the axis of the bearing. The maximum diameter of the cage when stationary is .944". The clearance between the cage and the inner race is .006". The chamfer on the outer race is at 60° to the axis of the bearing and extends between a diameter of .920" and a diameter of .959". The gap between the tapered surface of the cage and the edge of the chamfer is about .015" when stationary and may decrease to about .088" when running due to temperature expansion of the cage which is of nylon. The speed at which the bearing is to run is 24000 to 30000 r.p.m. Suitable oil is diethyl adipate or an oil in the classification D.T.D. 822. Axial location of the cage is by the oil ring in one direction and by the balls in the other direction. It will be seen that several thousandths of an inch axial movement can be permitted without making much difference to the size of the gap in which the oil ring is to be formed.

Lubricating oil may be fed by known means to the inner race of the bearing, and will be spread over the ball bearing surfaces, as is well understood. It will also be transferred through the ball-locating holes 10 in the cage 5 to the outer surface up which it will flow by centrifugal force to form the locating ring. When the bearing is stationary the oil ring 2 will be maintained in the gap by its surface tension so that subsequent operation will start under the proper conditions. The ball-locating holes 10 are preferably at an angle to the normal to the bearing axis. This angle is usually chosen as the estimated pressure angle of the bearing. The angle of the tapered part 6 of the cage surface may be in the same (Figure 3) or the opposite (Figures 1, 2 and 4) sense as the angle of the holes 10 with respect to the normal to the axis of the bearing. In the first case, the flow of oil to the non-parallel surface 6 is made easier, while if the angles are in the opposite sense, the oil ring 2 supports more of the axial thrust.

In practice it is found that the thermal expansion of a cage under certain operating conditions can be appreciable, and care must be taken that the precise dimensions of cage that are required should be the dimensions of the cage at the operating temperatures.

The life of a bearing according to the invention is found to be long due to the facts that there is less random movement of the cage by reason of its more precise location, and that the rubbing speed of the balls is more nearly constant.

What we claim is: —

1. A ball or roller journal bearing in which the cage is held in position radially by a narrow oil ring transverse to the journal and in contact with both the cage and the outer race.

2. A ball or roller journal bearing as claimed in claim 1 in which the surface of the cage has a portion of which the outside diameter is tapered axially, between the port of largest diameter of which portion of the surface and the outer race is defined an annular gap in which the oil ring will be established by oil flowing along the said portion of the surface of the cage.

3. A ball or roller journal bearing in which the surface of the cage has a portion of which the outside diameter is tapered axially, between which portion and the surface of the outer race is defined an annular gap in which there will be established, by oil flowing along the said

portion of the cage, an oil ring in contact with both the cage and the outer race.

4. A ball or roller journal bearing in which, over a part of the axial width of the cage, the outside diameter of any one section through the cage is greater or less than that of any other section according as the one section is nearer to, or further from, one side of the bearing than the other section, and in which the outer race is of such a size and shape that an annular throat is defined between a part of the surface of the outer race and the surface of the said part of the axial width of the cage, the throat being of such a size that oil flowing along the surface of the other part of the axial width of the cage will form a ring.

5. A ball or other journal bearing in which, over a part of the axial width of the cage, the outside diameter of any one section through the cage is greater or less than that of any other section according as the one section is nearer to, or further from one side of the bearing than the other section, and in which the outer race is of such a size and shape that an annular throat is defined between a part of the surface of the outer race and the surface of the said part of the axial width of the cage, the throat being of such a size in relation to the speed at which the bearing is intended to run and to the oil which it is intended to use in the bearing that oil flowing along the surface of the other part of the axial width of the cage will form a ring.

6. A ball or roller journal bearing in which the cage for maintaining the balls or rollers in spaced circumferential relation consists of an annular member of which the curved surface of larger diameter is at least in part not parallel to the bearing axis, along which tapered surface lubricating oil will flow from positions of smaller to positions of greater radius during rotation of the cage, the dimensions and configuration of the bearing being such that in operation the non-parallel surface will be so positioned in relation to a co-operating part of the outer race that the oil flowing along the tapered surface will collect in a ring held between the said surface and the said part of the outer race, on which ring of oil the cage will be located.

7. A ball or roller journal bearing as claimed in any one of the preceding claims in which the oil ring is formed in a throat between a sharp edge formed on the outer race and a (or the) tapered surface of the cage.

8. A ball or roller journal bearing as claimed in any one of the preceding claims in which a second similar oil ring is formed in a similar way between a position on the cage and a corresponding position on the outer race, which is displaced axially from the first oil ring, the arrangement being such that the two oil rings take thrust in opposite senses.

9. A ball or roller journal bearing constructed and arranged substantially as hereinbefore described and shown in any one of the figures of the accompanying drawing.

For the Applicants:
R. H. NISBET,
The Sperry Gyroscope Company Limited,
Great West Road, Brentford, Middlesex.

PROVISIONAL SPECIFICATION

Improvements in or relating to Ball Bearings

We, THE SPERRY GYROSCOPE COMPANY LIMITED, a British Company, of Great West Road, Brentford, Middlesex, do hereby declare this invention to be described in the following statement:—

This invention relates to low-power-loss ball and roller bearings. It relates more particularly to bearings having light thrust loads and to bearings in apparatus where the main load torque is that due to losses in the bearings and to windage. Gyroscopes are examples of such apparatus and these are frequently run in a vacuum to eliminate windage losses. Power loss in the bearings may apply torque to a gyroscope rotor causing precession which will require correction by reference instruments.

In general, power losses in bearings are due to two causes. There may be friction losses between the balls or rollers and the races, and between the cage and the balls or races, and also viscous drag due to lubricating oil between the surfaces of the various parts. Secondly there may be losses due to cage vibration which may have axial and radial components.

In order to reduce frictional losses light cages have been proposed, and it is known that cages of nylon are desirable because the viscous drag between nylon and oil is low, and its chemical inertness obviates sludging, i.e. the production of foreign bodies by chemical action, and in addition nylon has a low coefficient of friction and high wear-resistance.

To prevent losses due to vibration of the cage it is necessary to locate the cage precisely without introducing large frictional losses. Formerly cages were located on the balls but the location was of necessity not precise, and any tendency to sludge caused foreign bodies to be introduced between the balls and cage to increase friction losses, and in low-loss bearings it is necessary to have a certain minimum clearance between the balls and the cage to prevent these losses, which clearance is too great to provide precise location of the cage. It is therefore thought necessary to locate the cage with reference to the races.

According to the present invention, in a ball or roller bearing a cage for maintaining the

balls or rollers in spaced circumferential relation consists of an annular member (which may or may not be of nylon) of which the curved surface of larger diameter is at least in part not parallel to the bearing axis, along which non-parallel surface lubricating oil will flow from positions of smaller to positions of greater radius during rotation of the cage, the dimensions and configuration of the bearing being such that in operation the non-parallel surface will be so positioned in relation to a co-operating part of the outer race that the oil flowing along the non-parallel surface will collect in a ring held between the said surface and the said part of the outer race, on which ring of oil the cage will be located.

Oil transferred through the bearing will travel by centrifugal force as a film along the non-parallel surface to positions of increasing radius until it reaches the co-operating part of the outer race between which and the cage a gap is defined. The gap is designed to be of such a size that the oil film cannot pass through it without being restricted in dimension, the surface tension of the restricted film partly balancing the centrifugal force tending to cause the oil to move outwards so that the oil will collect in the gap as a ring shaped local concentration. The gap between the cage and the outer race may be of the order of .010″—.015″ for a race having an internal diameter of .5″ depending upon the viscosity of the oil used and the conditions, particularly the temperature, in the bearing. The ring of oil will act as a cushion opposing and damping radial vibration of the cage.

A preferred embodiment of the invention is shown by way of example in Figures 1 and 2. As shown, the part of the outer race 1 at which the oil ring 2 is formed has a chamfer 3 which provides a sharp edge 4 which, together with the cage 5 defines the gap or neck. This is shown more clearly in Figure 2 which is an enlarged view of a part of Figure 1. The non-parallel part 6 of the cage surface is terminated in a knife edge 7 to which any oil which passes through the gap or neck will travel, and from which it will be thrown off by centrifugal force on to the chamfer 3 on the outer race. It may then run down the chamfer into the neck forming a local circulating system or may be collected on an external soak and returned to the reservoir. In this form of the bearing a certain amount of thrust in the direction shown by the arrow 8 can be taken up by the oil in withstanding compression. Thus axial vibration of the cage can be reduced. It is preferred that the internal diameter of the cage should be just larger than the diameter of the inner race. For example, a difference in diameter of about .006″ is suitable for a .5″ bore bearing. This causes the cage to be located to some extent during running of the inner race so that wobble can be reduced. Any location of the cage that is necessary apart from the location on the oil ring 2 is given by the inner race rather than the outer because of the smaller relative linear speed between the cage and the inner race.

In another embodiment illustrated in Figure 3 the outer race is not chamfered but is provided with a groove 9 or recess at the desired position of the oil ring 2, which groove 9 will be supplied with oil moving up the non-parallel part 6 of the cage. In this case the sharp edge 7 of the cage runs on the oil in the groove 9. The groove 9 will be in the correct position both for collection of oil from the cage and for locating the cage.

In another example of the invention, shown in Figure 4, the outer surface of the cage 5 is generally spool-shaped having two surfaces 6, 6^1 of increasing radial dimension in opposite senses, the flat sides of the cage being formed with sharp edges 7, 7^1. In this example the outer race has two chamfers 3, 3^1, each of which is fed with oil from one of the sloping surfaces 6, 6^1 of the cage, and in each of which one of the edges 7, 7^1 of the cage is located. At the cost of slightly greater viscous drag this form of the invention provides substantial freedom from axial vibration of the cage in both directions.

In Figure 5 there is shown another example of the invention which is somewhat similar to that shown in Figure 4. In this case the outer race has two grooves 9, 9^1 in place of the two chamfers 6, 6^1 of Figure 3, each groove being fed with oil from the cage. One each of the edges 7, 7^1 of the cage run on the oil in each of the grooves 9, 9^1.

It is envisaged that the outer race may have an outside rim of smaller diameter than the ball bearing surface and joined to it by a chamfer, the oil gap being defined between the chamfer and the largest diameter edge of the cage. Oil flowing up the non-parallel part of the cage surface will collect between the edge of the cage and the chamfer, and the cage can be located on the ring of oil so formed as described above.

In Figure 6 there is shown an example of the invention applied to a roller bearing.

Lubricating oil may be fed by known means to the inner race of the bearing, and will be spread over the ball bearing surfaces, as is well understood. It will also be transferred through the ball-locating holes 10 in the cage 5 to the outer surface up which it will flow by centrifugal force to form the locating ring. When the bearing is stationary the oil ring 2 will be maintained in the gap by its surface tenson so that subsequent operation will start under the proper conditions. The ball-locating holes 10 are preferably at an angle to the normal to the bearing axis. This angle is usually chosen as the estimated pressure angle of the bearing. The angle of the non-parallel part 6 of the cage surface may be in the same (Fig. 3) or the opposite (Figs. 1, 2, 4 and 5) sense as the angle of the holes 10 with respect

to the normal to the axis of the bearing. In the first case, the flow of oil to the non-parallel surface 6 is made easier, while if the angles are in the opposite sense, the oil ring 2 supports more of the axial thrust.

In practice it is found that the thermal expansion of a cage under certain operating conditions can be appreciable, and care must be taken that the precise dimensions of cage that are required should be the dimensions of the dimensions of the cage at the operating temperatures.

The life of a bearing according to the invention is found to be long due to the facts that there is less random movement of the cage by reason of its more precise location, and that the rubbing speed of the balls is more nearly constant.

For the Applicants:
R. H. NISBET,
The Sperry Gyroscope Company Limited,
Great West Road, Brentford, Middlesex.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1954
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

719,829 PROVISIONAL SPECIFICATION

1 SHEET

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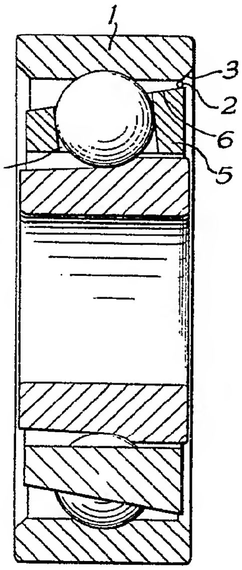


Fig.1.

Fig.4.

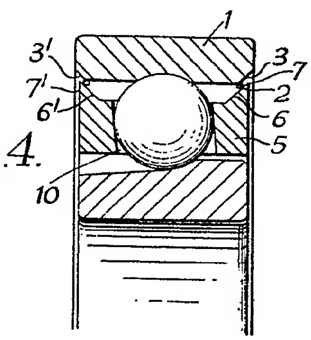


Fig.5.

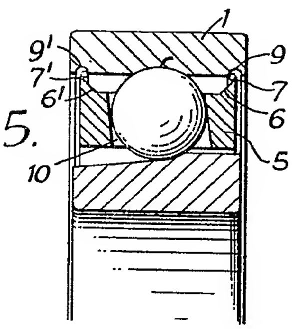


Fig.2.

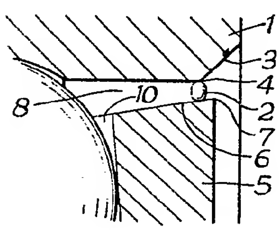


Fig.3.

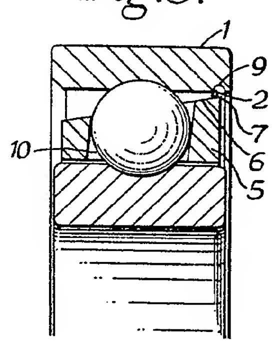
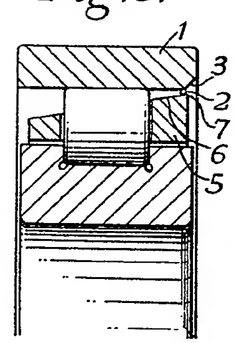


Fig.6.



719,829 COMPLETE SPECIFICATION
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Fig.1.

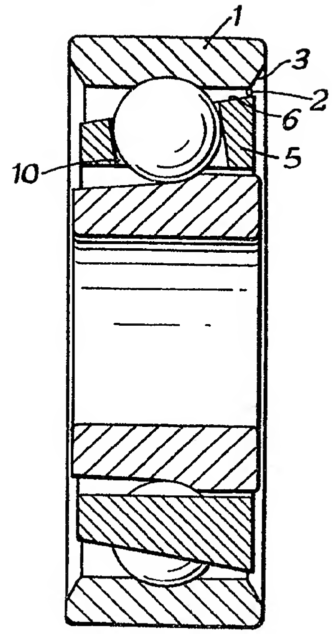

Fig.2.

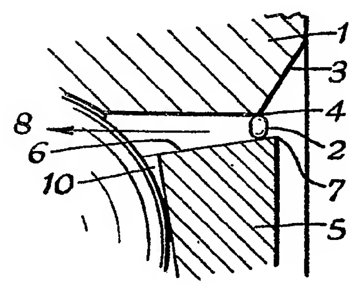

Fig.3.

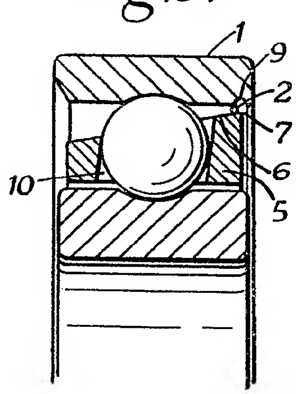

Fig.4.

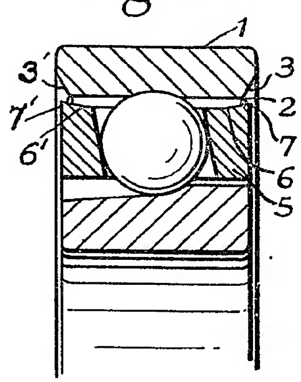

Fig.5.